THE INFLUENCE OF DENIER'S SCIENCE ON NOT ADDRESSING CLIMATE CHANGE

BY GORDON MCBEAN

UN SECRETARY-GENERAL ANTÓNIO GUTERRES – CLIMATE ACTION SUMMIT

The UN Secretary-General A. Guterres called on all national leaders to come to New York on 23 September 2019 for the Climate Action Summit to enhance action on greenhouse gas emissions reduction and stated [1]: "*Climate change is the defining challenge of our time.*" When the Climate Change Conference COP25 ended in December 2019 without agreements on moving ahead with emissions reductions, the Secretary-General stated: "*I am disappointed with the results of COP25. The international community lost an important opportunity to show increased ambition on mitigation, adaptation and finance to tackle the climate crisis.*" [2] Why do governments not act when there is strong scientific climate change evidence that emissions of greenhouse gases are driving the warming and there are major implications for global societies? Governmental responses are usually motivated by political support. Will actions on climate change be supported by voters in the next election?

Is the influence of climate change deniers and their "fake" science an important factor in reducing the motivations of governments to take actions? When climate change became the issue with the policy focus on reducing emissions of chemicals into the atmosphere to reduce the changes in the greenhouse effect, climate change denial information began to be conveyed through media and other sources to the global community to influence the actions that would be taken. Science-based knowledge on the globally changing climate and its societal implications is strong and based on highly credible sources. There are some questions that need to be further investigated but these issues are clearly not justification for inaction.

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SUMMARY

This essay examines science and pseudoscience, and its sources, addressing climate change that has been provided to the public and policy makers through assessments, reports and websites, and how this has influenced action.

This article draws my personal involvement in the climate change science and policy from the 1980's to the present and on many reliable sources in the literature and the valuable and consistent information in five books, whose titles are indicative: Bowen (2009) [3] *Censoring Science: Inside the political Attack on Dr. James Hansen and the Truth of Global Warming*; Mann (2012) [4] *The Hockey Stick and the Climate Wars*; Oreskes and Conway (2011) [5] *Merchants of Doubt*; Powell (2011) [6] *The Inquisition of Climate Science;* and, focussing on the Canadian scene, Hoggan and Littlemore (2009) [7] *Climate Cover-Up: The Crusade to Deny Global Warming* .

CLIMATE CHANGE – NOT A NEW SCIENCE ISSUE

The scientific basis [8] for understanding the climate system and its variability goes back over millennia, building on fundamental understanding of the physics and chemistry of the climate system. About 200 years ago, Fourier [9] developed the understanding of the greenhouse effect where the visible light from the Sun heats up the Earth and the greenhouse gases (water vapour, carbon dioxide, methane and others) absorb some of the Earth's outgoing radiation and send energy back down to the surface, further warming the Earth. Arrhenius (1896) [10] concluded that doubling the CO_2 in the atmosphere would raise the Earth's global temperature some 5-6 °C.

Over the following half-century there was further research on the issues of changing greenhouse gases leading to climate change. The International Council of Scientific Unions (ICSU) (now the International Science Council [11]) organized the International Geophysical Year (IGY) [12] (July 1957 to December 1958) to initiate the systematic measurements of carbon dioxide and ozone and other chemical components of the atmosphere, which continue. On October 4, 1957, Sputnik [13] was launched, leading the development of satellites to see Earth from space.

In 1979, World Meteorological Organization [14], ICSU and UN Environment Programme [15] jointly convened the first World Climate Conference, raising climate change to a higher political level. To scientifically address the concerns, the World Climate Research Programme (WCRP) [16] was

created to determine: "*the predictability of climate*"; and "*the effect of human activities on climate*". The words predictability and human activities highlight the policy concerns. With the rising international concerns about climate change and related issues of global environmental change, plus emerging discussions on sustainable development, ICSU founded, in 1986, the International Geosphere-Biosphere Programme (IGBP) [17] to: "*study earth system science and to help guide society onto a sustainable pathway during rapid global change.*"

THE 1980'S – NEW SCIENCE, ATTACKS ON IT AND THE CREATION OF THE IPCC

On June 23, 1988, Dr. J. Hansen, Director, NASA Goddard Space Institute gave testimony [18] to a U.S. Senate committee that "*the global warming is now large enough that we can ascribe with a high degree of confidence a cause and effect relationship to the greenhouse effect*", increasing public awareness of climate change [19]. This "*ignited public discussion of global warming and moved the controversy from a largely scientific discussion to a full blown science policy debate*" and marked "*the official beginning of the global warming policy debate*" [20]. What followed were political attacks on Hansen, as documented in Bowen's book and those of Mann, Powell and Oreskes and Conway.

In the mid-1980s there were other climate change science meetings and one report, chaired by Professor B. Bolin (Sweden), noting that greenhouse gases were increasing rapidly due to human activities, agreed on a concluding statement: "*Many important economic and social decisions are being made today on long-term projects, all based on the assumption that past climatic data, without modification, are a reliable guide to the future. This is no longer a good assumption.*" [21]

There were raising political concerns and several countries, led by the United States, expressed concerns about climate change assessments, prepared by independent scientists, having far-reaching implications for national and global economies. The Intergovernmental Panel on Climate Change (IPCC) [22] was created through a process led by Canadian J.P. Bruce [23]. The IPCC does not do research, but assesses and synthesizes the relevant results of peer-reviewed published research and other credible and open sources. The reports are to be policy-relevant but not policy-prescriptive. The IPCC is structured with three Working Groups. Working Group I "*examines the physical science underpinning past, present, and future climate change and uses a global network and participation of scientists to regularly assess the rich body of scientific literature, contributing to an ever-strengthening understanding of how the climate system works, and how it is changing in response to human activity.*" Working Group II assesses the impacts, adaptation and vulnerabilities related to climate change and Working Group III focuses on climate change mitigation, assessing methods for reducing greenhouse gas emissions and removing greenhouse gases from the atmosphere. The author teams for each chapter are appointed based on their scientific excellence and knowledge. The assessments identify where there is agreement in the scientific community on topics related to climate change and where further research is needed. The process has several steps, each with reviews, for objectivity and transparency. The assessment report chapters are the responsibility of chapter's lead authors and the draft Summary for Policy Makers is prepared by lead authors and approved, or modified, by governmental representatives at the formal IPCC Sessions.

IPCC ASSESSMENTS AND THE IMPACTS OF DENIAL

The advancements in science, the increased concentrations of greenhouses and the warming of the climate system have been reflected in the IPCC's assessments. The IPCC First Assessment Report (FAR, 1990) was presented to the Second World Climate Conference in 1990 and states: "*The observed increase (in temperatures) could be largely due to natural variability; alternatively this variability and other man-made factors could have offset a still larger man-made greenhouse warming.*"

The IPCC Second Assessment Report (1995) was presented to the Climate Convention Conference of Parties (CoP2) in 1996, in Geneva, and then conveyed to CoP3 in 1997 in Kyoto (Kyoto Protoco[l]). There was major debate on the question of whether climate was changing and the influence of human activities. The scientific analysis of Dr. B. Santer [4] of the US Department of Energy's Lawrence Livermore National Laboratory was key, leading to the original proposed wording: "*balance of evidence suggests an appreciable human influence on climate*" which raised concerns of oil states. In the end, the compromise was: "*the balance of evidence suggests a discernible human influence on climate*". Later that year, the governments held their formal meeting[1] to review the summary for policymakers and this phrase was further debated. The representatives of the Global Climate Coalition [24] attended, as observers, and encouraged oil country representatives to collectively object to this terminology. IPCC Chair B. Bolin proposed, and it was agreed, that a footnote be added that said which countries objected to this wording. As the meeting was ending and it was clear that this version with the footnote would be published, the objecting countries formally asked that the footnote be withdrawn.

The "*attacks*" against Dr. Santer [25] ratcheted up dramatically following the Plenary Session which formally approved the Second Assessment Report. The Global Climate Coalition and the George C Marshall Institute [26] (founded by Professor F. Seitz and others and funded by industry; it was converted, in 2015, to be the CO2 Coalition [27]), circulated reports in Washington and in the media accusing Dr. Santer of abusing the peer review system and "*political tampering*" and "*scientific cleansing*". The IPCC chair and

1. G. McBean was the Canadian representative at the IPCC meeting, as then an Assistant Deputy Minister, Environment Canada.

co-chairs supported Santer, asserting that all proper IPCC procedures had been followed in producing the chapter.

IPCC THIRD ASSESSMENT REPORT (2001) AND THE "HOCKEY STICK"

The IPCC Third Assessment Report (TAR) concluded that: "*There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities.*" The crucial scientific papers were three co-authored journal papers, with Mann (2012) as lead author. The graph of northern hemisphere average temperature was nick-named the "*hockey stick*" due to its shape. The IPCC's conclusions were attacked by a Canadian academic [28, 29] and a mining industry executive [30] (who created the blog called Climate Audit [31]). They claimed that the hockey stick shape was scientifically incorrect and its shape was not statistically significant. An independent assessment of Mann's hockey stick (Wahl, 2007) [32] confirmed the principal results that the warming trend and temperatures over the last few decades were unprecedented over at least the last 600 years.

In 2002 (with a new version in 2007), two Canadian academics published a book *Taken By Storm* [33] *in which they state:* "*We have shown, page after page, that certainty on the subject of the future direction of climate is impossible ... that anyone who thinks we can predict the climate only courts the laughter of the gods...*" They continue to speak out on these issues, including in a June 2019 opinion article [34] entitled: "*This scientist proved climate change isn't causing extreme weather — so politicians attacked. And so, many scientists who have the facts and know the truth remain silent."* The article was mostly quoting an American academic [35] who denies [36] the role of climate change in causing more weather disasters.

IPCC 4TH AND 5TH ASSESSMENT REPORTS

The IPCC Fourth Assessment Report (2007) stated: "*Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations*." The IPCC Fifth Assessment Report (2013-14) concluded: "*Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia.*" And that: "*Human influence has been detected in warming of the atmosphere and the ocean, in changes in the global water cycle, in reductions in snow and ice, in global mean sea level rise, and in changes in some climate extremes. This evidence for human influence has grown since AR4 (2007). It is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century*."

CANADIAN SCENE

As noted, there have been active climate change deniers in Canada. The Friends of Science [37], as an example, has as its goal: "*To educate the public about climate science and through them bring pressure to bear on governments to engage in public debates on the scientific merits of the hypothesis of human induced global warming and the various policies that intend to address the issue*". They state that: "*It is our opinion that the Sun is the main direct and indirect driver of climate change.*" Their publications and presentations continue to deny climate change caused by human activities and to attack climate scientists. An active member of Friends of Science, T. Ball, has many publications denying climate change and has been involved in lawsuits [38, 39]. A columnist [40] for the Financial Post has consistently argued against climate change as an issue and against any action addressing it. On December 13, 2019 he suggested that "*the UN's climate catastrophe scenarios are way off the mark*" [41] and on October 17, 2018, he wrote about "*why-insurers-keep-hyping-climate-risks-that-don't-materialize*" [42].

The role of governments in supporting or controlling science is analysed by Turner (2013) in his book *The War on Science* [43] where he described the muzzling of science on the climate change and other issues.

In April 2019, the city of London, Ontario, declared a climate emergency with a strong positive vote (12-3), joining with other Canadian cities, including Halifax, Kingston and Vancouver, in making similar declarations [44]. On November 25, 2019, the City Council's Strategic Priorities and Policy Committee met to discuss the Climate Change Emergency Update. Three days earlier (November 22) Councillor M. van Holst [45] submitted a motion, quoting the Global Warming Prediction Project [46], "*There is no convincing scientific evidence that human release of carbon dioxide, methane, or other greenhouse gasses is causing or will, in the foreseeable future, cause catastrophic heating of the Earth's atmosphere and disruption of the Earth's climate. Moreover, there is substantial scientific evidence that increases in atmospheric carbon dioxide produce many beneficial effects upon the natural plant and animal environments of the Earth*". He went on to say: "*If this (demonized and shouted down) Carbon-dioxide-is-good narrative is true, then we will be wasting a great deal of time and money on actions that will produce nothing of value and set us back greatly in our goal to tackle the more tangible problems with which we are plagued.*" After some discussion, the motion to refer the report back to the staff for reconsideration was defeated, 11 votes to 2 [47] and the community's Climate Emergency Action Plan [48] is moving ahead. The CBC News in London interviewed four scientists (including the author of this article) about the scientific credibility of the Petition and all agreed that its climate claims were "*false or misleading*" [49].

THE EARTH'S CHANGING CLIMATE AND NEED FOR ACTION

In view of the preceding information on climate change and denials, what is the situation now regarding climate science and actions. The importance of and calls for action on climate change have been based on highly-credible, science assessments, including the: United In Science High-level synthesis

report [50] of latest climate science information from the contributing agencies, including the: World Meteorological Organization (WMO); United Nations Environment Programme (UNEP); Intergovernmental Panel on Climate Change (IPCC); and Future Earth [51] research programme. Other important information is in Canada's Changing Climate Report [52] and the special reports of the IPCC (Global Warming of 1.5 °C (2018); Ocean and Cryosphere in a Changing Climate (2019) and Climate Change and Land (2019)). The atmospheric averages concentrations of two of the most important greenhouse gases have increased since 1750 to present, for carbon dioxide from 280 ppm to 410 ppm and for methane from 700 ppb to 1800 ppb (over double) (Fig. 1).

Most of the increases have occurred in the past century and most rapid increases in the past few decades as direct affect of growing population, industrialization and transport based on fossil fuels, agriculture for methane and other societal sources. The average global temperature for 2015-2019 was 1.1 °C (± 0.1 °C) above pre-industrial (1850-1900) times and the warmest period on record. The NOAA [53] report on 16 January 2020 states that "*The five warmest years in the 1880–2019 record have all occurred since 2015, while nine of the 10 warmest years have occurred since 2005.*" Sea level has risen, and sea-ice extent and glacier mass have been reduced. Canada's climate has warmed over the last few decades at a rate of about double the magnitude of global warming and the Canadian arctic has warmed about three times the global rate and the warming will continue in the future, driven by human influence. An overview from the Royal Society and the US National Academy of Sciences (2020) [54] on Climate Change: Evidence and Causes: Update 2020, states in its summary: "*Detailed analyses have shown that the warming during this period is mainly a result of the increased concentrations of CO***2** *and other greenhouse gases*". The Intergovernmental Panel on Climate Change is in the process of preparing its Sixth Assessment Report, Climate Change (2021-2).

As the decade of 2020's moves ahead, it is important to recognize how important it is for all humanity to address the Earth's changing climate now and in the future. The World Economic Forum (WEF) [55] is an international organization of high credibility to most government leaders. The WEF Global Risk Reports assess, in terms of impact and likelihood, the global risks which are defined as an uncertain event or condition that, if it occurs, can cause significant negative impact for several countries or industries within the next 10 years. The 2020 Report [56] executive summary states: "*Climate change is striking harder and more rapidly than many expected."* The Report ranks: *Failure of climate change mitigation and adaption* as the number one risk by impact and number two by likelihood over the next 10 years, and *Extreme weather events* (e.g., floods, storms) as the highest in likelihood and 4th highest in terms in impacts. Worldwide economic stress and damage from natural disasters in 2018 totalled US$165 billion, and 50% of that total was uninsured [57]. Climate-related economic damage in the United States could reach 10% of GDP by the end of the century [58]. In the private sector, there is recognition of the costs of climate change with nonaction (nearly US$1 trillion) and the significant benefits of right strategies [59]. The losses will be distributed unequally, with the highest economic costs being felt by large economies, while risks of exposure, death and non-economic costs are higher in smaller, poorer economies [60], raising the issues of international equity and ethics. Extreme weather is impacting Canada with the average annual insurance disaster payments, inflation adjusted, exceeding $B Canadian 2.1 for 2016-18, and there are additional societal costs. The estimated annual direct physical damage costs (Fig. 2) are increasing and the projections for 2030 and beyond are in the $10B to $15B range and higher beyond.

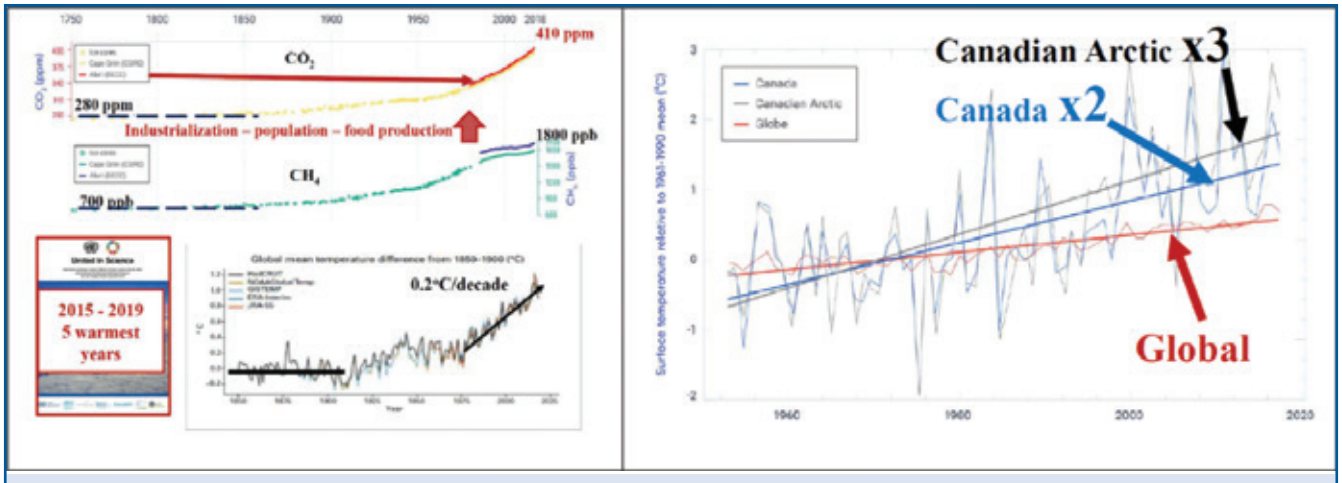

Fig. 1 Left: Global average changes in greenhouse gas concentrations and temperature – from United in Science Report [50]. Right: the observed warming in Canada and Canadian Arctic compared to global warming [52].

To reduce these costs, there is need to both reduce emissions to reduce the longer-term climate change and to adapt through making adjustments in our decisions, activities and thinking because of the changes in climate, in order to moderate harm or take advantage of new opportunities.

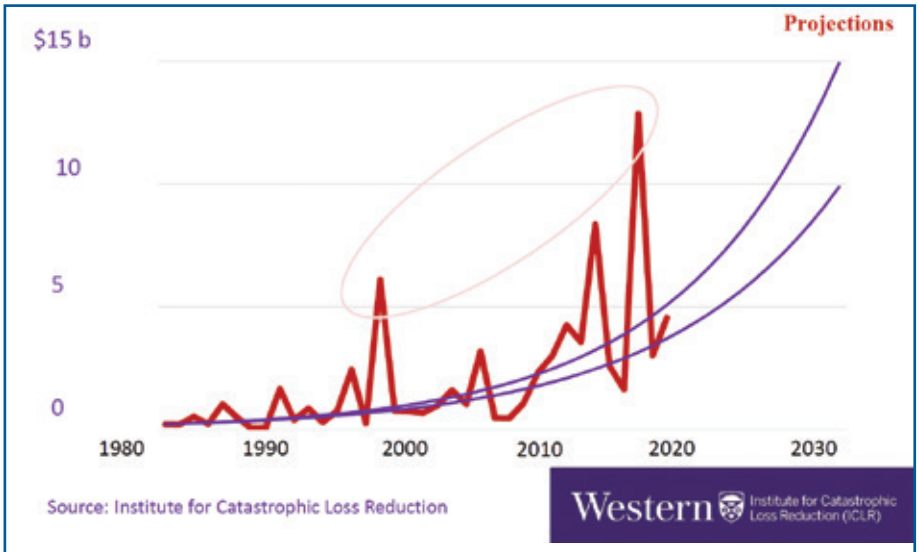

Fig. 2 Estimated annual direct physical damage, $B Canadian, adjusted for inflation (ICLR [61]).

CONCLUDING COMMENTS

In the opinion of this author and almost all climate scientists in Canada and around the world, the climate has warmed, with the past five years being the warmest since humans have been on this planet and the human influence has been the dominant cause of the observed warming since the mid-20th century. The social and economic costs of a changing climate are substantial and much larger than the costs of acting — reducing emissions and adapting to climate change and reducing disaster risk. Polls [62] show that the majority of Canadians agree with action on climate change. Climate change was a dominate factor in Canada's October 2019 election [63]. Former Governor of the Banks of England and Canada Mark Carney has been appointed United Nations Special Envoy for Climate Action and Finance and he says: "*I would say we're in a climate crisis ... action needs to be taken*" [64]. There is need for Canadians and the global community to act on this issue of intergenerational and international equity and ethics.

REFERENCES

1. United-in-Science report. https://public.wmo.int/en/media/press-release/landmark-united-science-report-informs-climate-action-summit.
2. UN Secretary-General. https://www.un.org/sg/en/content/sg/statement/2019-12-15/secretary-generals-statement-the-results-of-the-un-climate-change-conference-cop25.
3. M. Bowen, 2009: *Censoring Science. Inside the political attack on Dr. James Hansen and the truth of global warming*. Penguin Group, New York, ISBN: 978-0-452-28962-8, 324 pp.
4. M. Mann, 2012: *The Hockey Stick and the Climate Wars.* Columbia University Press. ISBN: 978-0-231-15254-9. 395 pp.
5. N. Oreskes and E.M. Conway, 2011: *Merchants of Doubt*. Bloomsbury Press. ISBN: 978-I-60819-394-3, 355 pp.
6. J.L. Powell, 2011: *The Inquisition of Climate Science*. Columbia University Press. ISBN: 978-0-231-15718-6. 232 pp.
7. J.L. Hoggan and R. Littlemore, 2009: *Climate Cover-Up: The Crusade to Deny Global Warming*. Greystone Books, Vancouver. ISBN: 9781553654858. 265 pp.
8. S. Weart, 2019: *The Discovery of Global Warming*. American Institute of Physics (AIP). http://www.aip.org/history/climate. (Based on a book of same title, published by Harvard University press, 2009).
9. J. Fourier, 1824: Remarques Générales Sur Les Températures Du Globe Terrestre Et Des Espaces Planétaires. *Annales de Chemie et de Physique,* **27,** 136-67. Fourier, J., 1827: "Mémoire Sur Les Températures Du Globe Terrestre Et Des Espaces Planétaires." Mémoires de l'Académie Royale des Sciences, **7**, 569-604.
10. S. Arrhenius, 1896: On the Influence of Carbonic Acid in the Air Upon the Temperature of the Ground. *Philosophical Magazine*, **41**, 237-76.
11. International Science Council https://council.science/.
12. G.A. McBean, 2018: Integrating Global Science to Address the Global Agenda 2030, *Environment: Science and Policy for Sustainable Development*, **60**, 6, 26-38, DOI: 10.1080/00139157.2018.1517517.
13. Sputnik. https://history.nasa.gov/sputnik/igy.html.
14. World Meteorological Organization (WMO) https://public.wmo.int/en.
15. United Nations Environment Programme (UNEP) https://www.unenvironment.org/.
16. World Climate Research Programme. http://www.wcrp-climate.org/.

17. International Geosphere-Biosphere Programme. http://www.igbp.net/.
18. J. Hanen, Senate testimony. https://www.sealevel.info/1988_Hansen_Senate_Testimony.html.
19. S.R. Weart, 2003: The Discovery of Global Warming. Harvard U. Press, ISBN: 0-674-03189-x, 240 pp.
20. T.M. O'Donnell, 2000: Of loaded dice and heated arguments: Putting the Hansen-Michaels global warming debate in context. *Social Epistemology,* **14**(2-3), 109-127. Doi:10.1080/02691720050199199.
21. Climate science and policy. https://council.science/current/blog/the-origins-of-the-ipcc-how-the-world-woke-up-to-climate-change/ and Bolin, B., 2007: *A History of the Science and Politics of Climate Change: The Role of the Intergovernmental Panel on Climate Change*. Cambridge University.
22. Intergovernmental Panel on Climate Change (IPCC). https://www.ipcc.ch (Note: all IPCC reports that are referenced are available on this website – under reports.)
23. J.P. Bruce, 2001: Intergovernmental Panel on Climate Change and the role of science in policy. *Isuma: Canadian Journal of Policy Research*, SSN: 1492-0611, **2**, 11-15.
24. Global Climate Coalition. https://www.climateliabilitynews.org/2019/04/25/gcc-global-climate-coalition-un-fossil-fuels/.
25. Attacks on Santer. Climate Science Legal Defense Fund (CSLDF) https://www.csldf.org/2017/12/26/perspectives-scientists-become-targets-ben-santer/.
26. George C Marshall Institute. https://www.desmogblog.com/george-c-marshall-institute.
27. CO2 Coalition. https://co2coalition.org/.
28. R. McKitrick, https://www.fraserinstitute.org/profile/ross-mckitrick.
29. R. McKitrick, https://www.desmogblog.com/ross-mckitrick.
30. S. McIntyre, https://www.desmogblog.com/steve-mcintyre.
31. Climate Audit. https://climateaudit.org/.
32. A. Wahl, 2007. https://link.springer.com/article/10.1007/s10584-006-9105-7.
33. C. Essex and R. McKitrick, 2007: *Taken by Storm: The Troubled Science, Policy, and Politics of Global Warming*. Key Porter Books.
34. R. McKitrick, https://business.financialpost.com/opinion/ross-mckitrick-this-scientist-proved-climate-change-isnt-causing-extreme-weather-so-politicians-attacked.
35. R. Pielke, https://sciencepolicy.colorado.edu/about_us/meet_us/roger_pielke/.
36. Pielke science. https://skepticalscience.com/print.php?r=462.
37. Friends of Science Friends of Science | Providing Insight into Climate Change.
38. https://pressprogress.ca/rebel-medias-climate-denial-expert-was-too-dumb-to-be-sued-for-defamation-bc-court-rules/.
39. https://www.huffingtonpost.ca/entry/climate-science-deniers-credibility-tested.
40. T. Corcoran, https://nationalpost.com/tag/terence-corcoran.
41. https://business.financialpost.com/opinion/terence-corcoran-here-are-the-signs-of-hope-gretas-desperate-for-that-show-therell-be-no-climate-apocalypse.
42. https://business.financialpost.com/opinion/terence-corcoran-why-insurers-keep-hyping-climate-risks-that-dont-materialize.
43. C. Turner, 2013: *The War on Science*. Greystone Books, 170 pp.
44. A. Graham, 23 April 2019: London city councillors declare climate emergency. 980 CFPL. https://globalnews.ca/news/5196624/london-climate-emergency/.
45. https://www.london.ca/city-hall/city-council/Pages/Ward-1.aspx.
46. Global Warming Petition Project http://www.petitionproject.org/.
47. Global News https://globalnews.ca/news/6218010/london-city-staff-climate-change-recommendations-committee/.
48. Climate Emergency Action Plan Climate Emergency Action Plan | Get Involved London.
49. CBC https://www.cbc.ca/news/canada/london/london-ontario-climate-crisis-denial-fact-check-michael-van-holst-1.5372239.
50. https://public.wmo.int/en/media/press-release/landmark-united-science-report-informs-climate-action-summit.
51. Future Earth. Research, Innovation, Sustainability, https://futureearth.org/.
52. Canada's Changing Climate Report – April 2019. Bush, E. and Lemmen, D.S., editors (2019): Canada's Changing Climate Report; Government of Canada, Ottawa, ON. 444 p. www.ChangingClimate.ca/CCCR2019.
53. https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature.
54. National Research Council 2020. Climate Change: Evidence and Causes: Update 2020. Washington, DC: The National Academies Press. https://doi.org/10.17226/25733.
55. https://www.weforum.org/.
56. https://www.weforum.org/reports/the-global-risks-report-2020.
57. Swiss Re Institute. 2019. "Nature Catastrophes and Man-Made Disasters in 2018: 'Secondary' Perils on the Frontline". https://www.swissre.com/dam/jcr:c37eb0e4-c0b9-4a9f-9954-3d0bb4339bfd/sigma2_2019_en.pdf.
58. National Climate Assessment. 2018. Fourth National Climate Assessment. Volume II: Impacts, Risks, and Adaptation in the United States. NCA. https://nca2018.globalchange.gov/.
59. M. Green, 2019. "World's Biggest Firms Foresee $1 Trillion Climate Cost Hit". Reuters. 4 June 2019. https://www.reuters.com/article/us-climate-change-companies-disclosure/worlds-biggest-firms-foresee-1-trillion-climate-cost-hit-idUSKCN1T50CF.

60. K. Ricke, L. Drouet, K. Caldeira and M. Tavoni, 2018 (correction 25 March 2019). Country-Level Social Cost of Carbon. *Nature Climate Change*, **8**(2018), 895-900.
61. Institute for Catastrophic Loss Reduction (ICLR) https://www.iclr.org/.
62. Majority of Canadians and Americans agree on climate change issues, poll suggests | CBC News.
63. The Economist https://www.economist.com/the-americas/2019/10/10/climate-change-dominates-canadas-election.
64. https://www.bbc.com/news/business-50868717.